TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 826

VARIATION OF PROPERTIES THROUGHOUT CROSS SECTION OF TWO EXTRUDED SHAPES

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SUMMARY

Tensile and compressive properties were determined of specimens cut from the fins and the main bodies of two different extruded shapes of 24S-T aluminum alloy. The specimens from the fins as compared with those from the main body of the section showed: tensile strengths from 5000 to 10,000 pounds per square inch lower; tensile yield strengths and compressive yield strengths 4000 to 9000 pounds per square inch lower. The compressive yield strength values for any given location in the cross sections were about 1000 to 6000 pounds per square inch lower than the tensile yield strength values for the same location.

INTRODUCTION

In connection with the use of extruded shapes in the construction of aircraft, the question has arisen as to how well the test results obtained on a specimen cut from a shape of irregular cross section represent the properties of the section as a whole. Samples of two 24S-T extruded shapes, K-16840 and K-16841, each of which consists essentially of a solid rectangular section with relatively thin fins extending from it, were selected for investigation.

The fins of these shapes have a nominal thickness of 0.140 inch, which, according to one interpretation, would mean that tension test specimens taken from these fins would be required by Federal Specification No. QQ-A-354 or Navy Department Specification No. 46A9c to show a minimum tensile strength of 57,000 pounds per square inch, a minimum yield strength of 42,000 pounds per square inch, and at least 12 percent elongation in 2

inches. If the specimens were taken from the solid rectangular portion, however, they would be required to meet minimum requirements of a tensile strength of 60,000 pounds per square inch, yield strength of 44,000 pounds per square inch, and 12 percent elongation in a gage length of four diameters. It is the belief of the Aluminum Company of America that it is intended by the specifications mentioned to require that specimens be taken from the solid rectangular portion. There are no specification requirements as to compressive yield strength, but it is generally assumed that the compressive yield strength is equal to the tensile yield strength.

The object of the reported tests was to determine the tensile properties of specimens cut from different locations in the cross sections of two extruded shapes, K-16840 and K-16841. The compressive yield strengths of corresponding compression test specimens were also determined.

SPECIMENS AND TESTS

The two shapes in question are shown in figure 1 and the specimens cut therefrom are shown in figure 2. Two flat tension test specimens of type 5 of Federal General Specification for Inspection of Metals QQ-M-151a (fig. 2 of A.S.T.M. Tentative Methods of Tension Testing of Metallic Materials (E 8 - 40 T)) were taken from a fin of each shape and two round tension test specimens of type 1 of QQ-M-151a (fig. 3 of E 8 - 40 T) were taken from the large rectangular portion of each shape. In addition to these specimens, one large specimen similar to figure 2 (type 2) of QQ-M-151a and figure 1 of E 8 - 40 T was taken from the main rectangular portion of each shape. These large specimens were made to include as much of the cross section as practical. Compression test specimens were also machined from the same portions of the two sections.

The tension test specimens of type 1 are the standard 1/2-inch diameter specimens taken from the sections in accordance with the requirements of Federal Specification QQ-A-354 and Navy Department Specification 46A9c, both of which state that "for material 1/2 inch or more in diameter or thickness which is not tested in full section, a test specimen of type 1 or type 4 (subsize specimen) . . . may be used."

Stress-strain tests (table I) were made on all specimens using a Ewing extensometer for measuring strains on the specimens of types 5 and 1 and a Martens mirror-type extensometer for measuring strains on the large tension specimens. The Martens instrument was used in all of the compression tests except those made by the pack method, where Huggenberger tensometers were used. The tensometers were used on 1/2-inch gage lengths; in all the other tests gage lengths of 2 inches were used.

RESULTS AND DISCUSSION

The stress-strain curves for all tests (only one of type 5 specimens for each shape) are plotted in figure 3 to 10 and the location of each specimen is indicated. The properties are summarized in table I. This table shows the types of specimen, their dimensions and locations in the cross sections, and the properties resulting from the tensile and compressive tests. It will be noted that the properties determined on specimens from the thin fins are definitely lower than those determined on either the round specimens from the heavy portions of the sections or those determined on the large rectangular specimens from the heavy portions of the sections. This result is true of the values for tensile strength and for both tensile and compressive yield strengths. All the properties were above the specification requirements. The tensile strength values ranged from about 17,000 to 24,000 pounds per square inch above minimum requirements and the tensile yield strength values were about 16,000 pounds per square inch above minimum requirements. The compressive yield strength values ranged from 1000 to 5700 pounds per square inch below the tensile yield strength values.

The macrographs in figure 11 show that there is a thin layer of coarse grains extending around the perimeter of each section. These coarse-grained portions are of lower strength than the fine-grained interior and, since the fins have a coarse-grained layer on each side of the thin section, the properties of these fins are definitely lower than the main body of the section, which has only a small percentage of the coarse-grained surface layer.

CONCLUSIONS

As a result of the tests described in this report, the following conclusions seem warranted:

1. The average tensile properties of the two shapes as represented by the results of tests on specimens taken in accordance with Federal and Navy specifications are as follows:

	K-16840	K-16841
Tensile strength, lb/sq in.	83,210	84,240
Yield strength (offset = 0.2 percent), lb/sq in.	61,550	67,050
Elongation in 2 inches, percent . . .	13.5	12.5

2. The average compressive yield strength values obtained from tests of compression specimens taken from locations corresponding to those prescribed for tensile specimens by Federal and Navy specifications are as follows:

	K-16840	K-16841
Compressive yield strength (offset = 0.2 percent), lb/sq in.	58,400	61,500

3. Specimens from the fins of the two sections showed tensile strengths 5000 to 10,000 pounds per square inch lower than specimens from the main body of each section.

4. Specimens from the fins of the two sections showed tensile yield strengths 4000 to 9000 pounds per square inch lower than specimens from the main body of each section.

5. Specimens from the fins of the two sections showed compressive yield strengths 4000 to 9000 pounds per square inch lower than specimens from the main body of each section.

6. The compressive yield strength values for any given location in the cross sections were about 1000 to 6000 pounds per square inch lower than the tensile yield strength values for the same location.

7. All tensile specimens cut from the two extruded shapes exhibited properties meeting the requirements of Federal Specification QQ-A-354 and Navy Department Specification 46A9c.

Aluminum Research Laboratories,
Aluminum Company of America,
New Kensington, Penna., July 29, 1941.

TABLE I.- RESULTS OF TENSION AND COMPRESSION TESTS ON SPECIMENS FROM DIFFERENT LOCATIONS IN CROSS SECTIONS OF 24S-T EXTRUDED SHAPES FROM DIE NOS. K-16840 AND K-16841

Extruded shape	Location from which specimen was cut	Type of tension specimen		Dimensions of tension specimen (in.)	Tensile strength (lb/sq in.)	Tensile yield strength (Offset=0.2 percent) (lb/sq in.)	Elongation in 2 inches (percent)	Dimensions of compression specimen (in.)	Compressive yield strength (Offset=0.2 percent) (lb/sq in.)
		Fed. Spec. QQ-M-151a (type)	A.S.T.M. E8-40T (fig.)						
K-16840	Fin	5	2	0.134x0.4975[a]	74,645[a]	56,200[a]	13.0	0.4042x0.6252[b]	51,700
	Body	1	3	0.498	81,720	60,600	14.5	0.625	59,600
	Body	1	3	.498	84,700	62,900	12.5	.625	57,200
	Body	2[c]	1[c]	1.0035x2.000	81,120	60,000	17.0	1.003x2.003	56,500
K-16841	Fin	5	2	0.1345x0.4995[a]	75,520[a]	58,450[a]	15.5	0.4037x0.6250[b]	53,400
	Body	1	3	0.498	84,450	67,400	12.5	0.6255	62,000
	Body	1	3	.498	84,030	66,700	12.5	.624	61,000
	Body	2[c]	1[c]	0.873x0.999	80,270	63,500	15.0	0.873x0.999	57,000

[a]Average of two tests; first specimen broke through extensometer marks.
[b]Pack compression specimen made up of three pieces about 0.135 inch thick.
[c]Standard dimensions except as to width of reduced section.

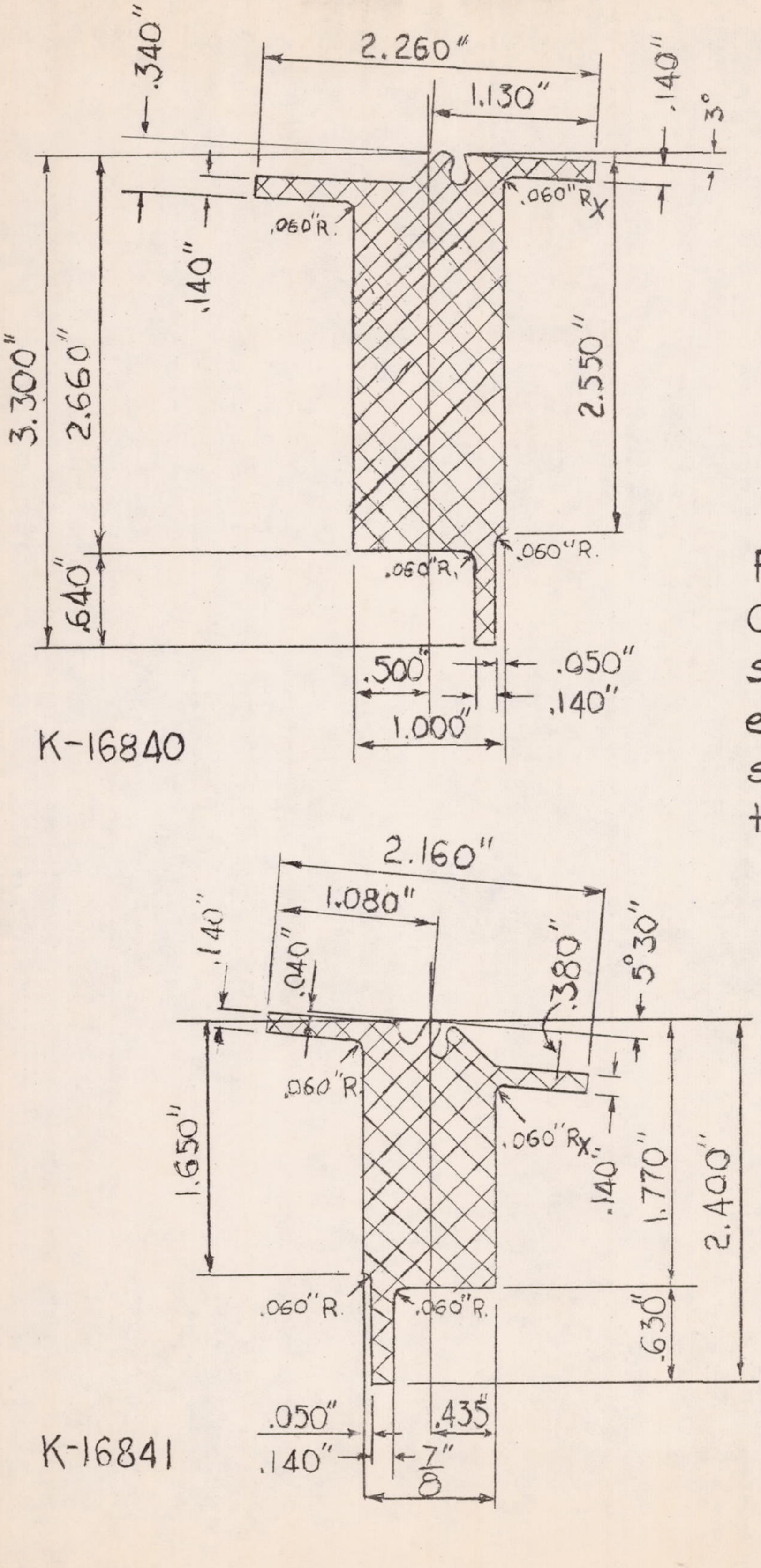
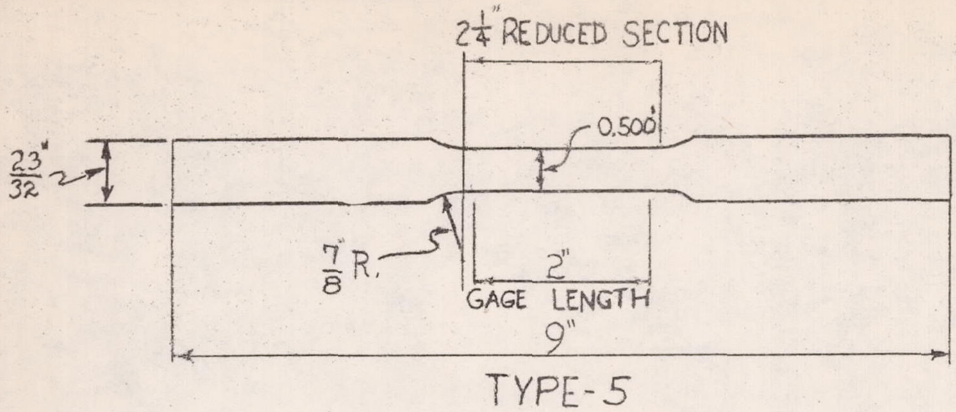
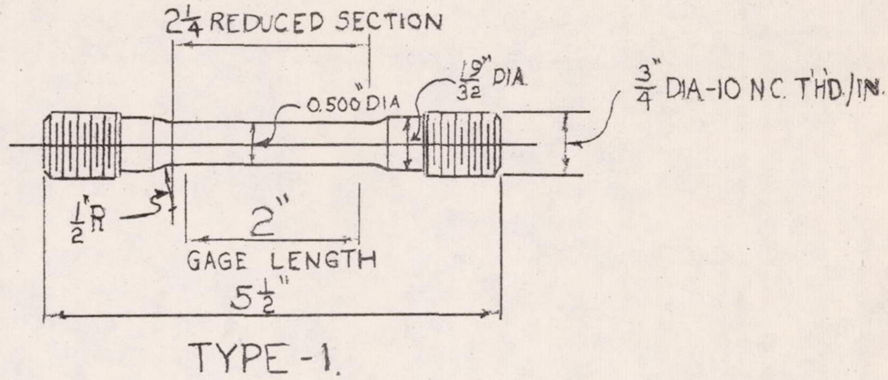
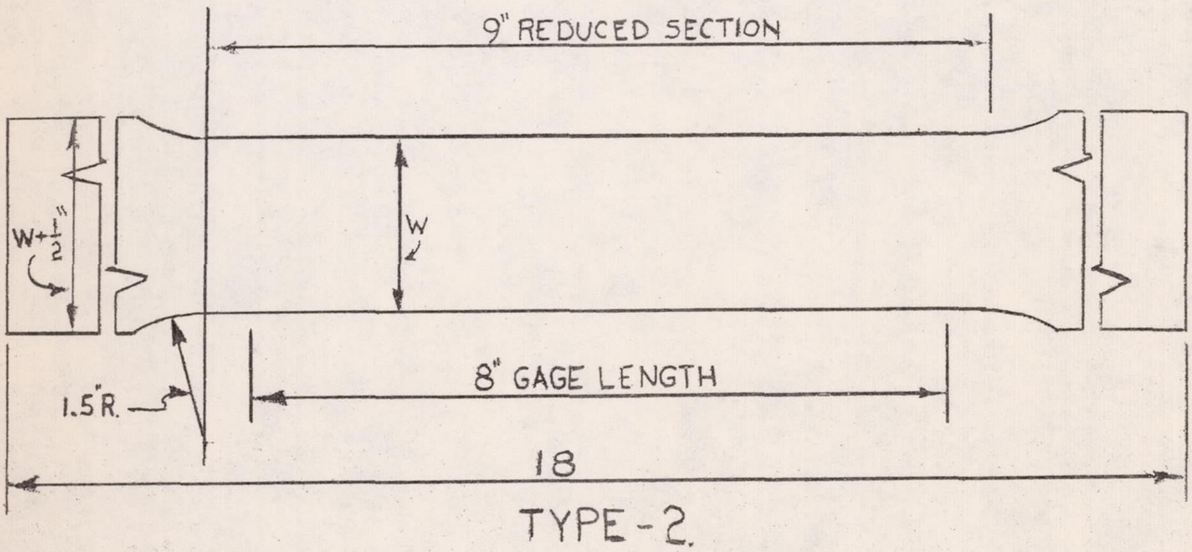


Figure 1.- Cross section of extruded shapes tested.







FOR SECTION K-16840, W=2 INCHES, THICKNESS=1 INCH
FOR SECTION K-16841, W=1 INCH, THICKNESS=$\frac{7}{8}$ INCH

FIG. 2 - DIMENSIONS OF TENSION TEST SPECIMENS

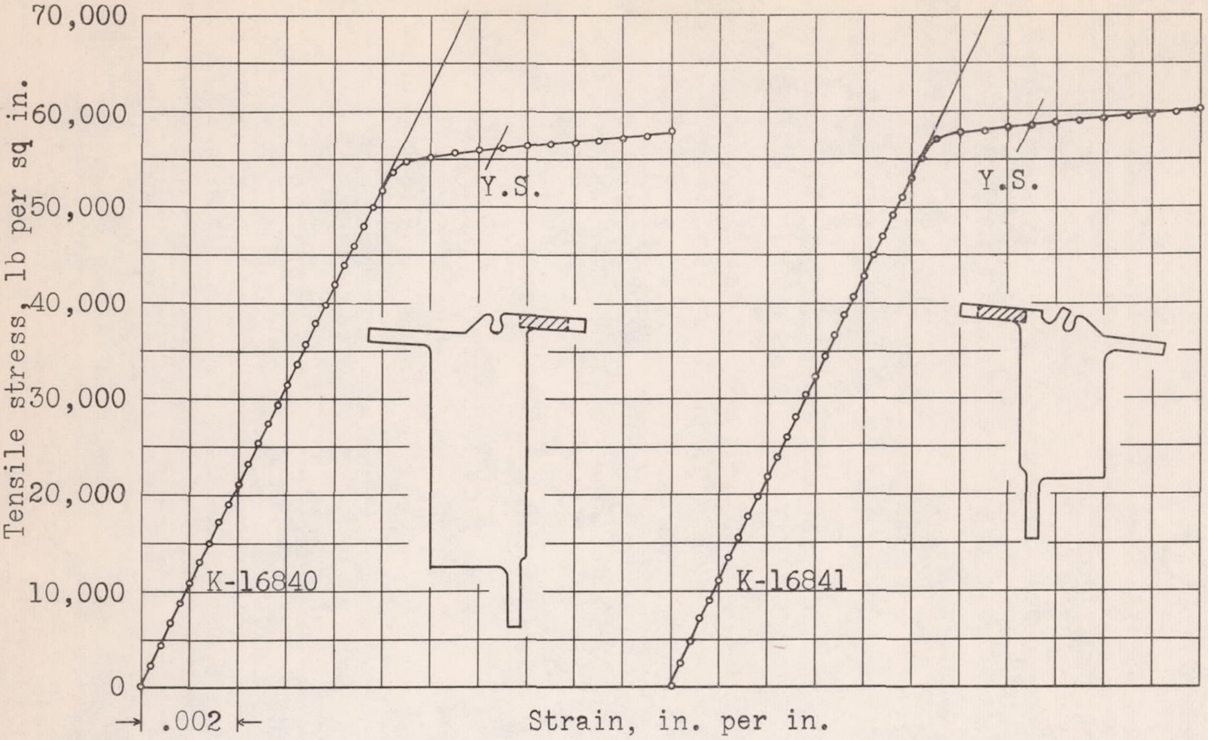


Figure 3.- Tensile stress-strain curves for 24S-T aluminum-alloy extruded shapes. Ewing extensometer used;2-inch gage length.

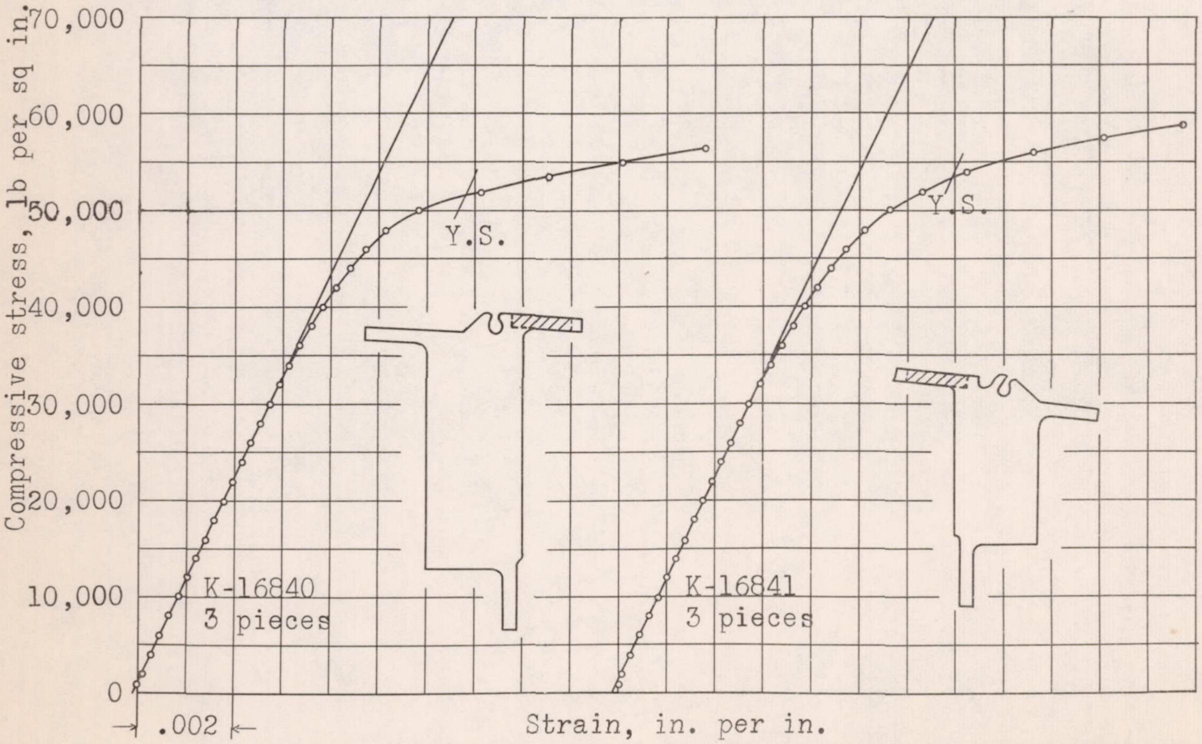


Figure 4.- Compressive stress-strain curves for 24S-T aluminum-alloy extruded shapes.

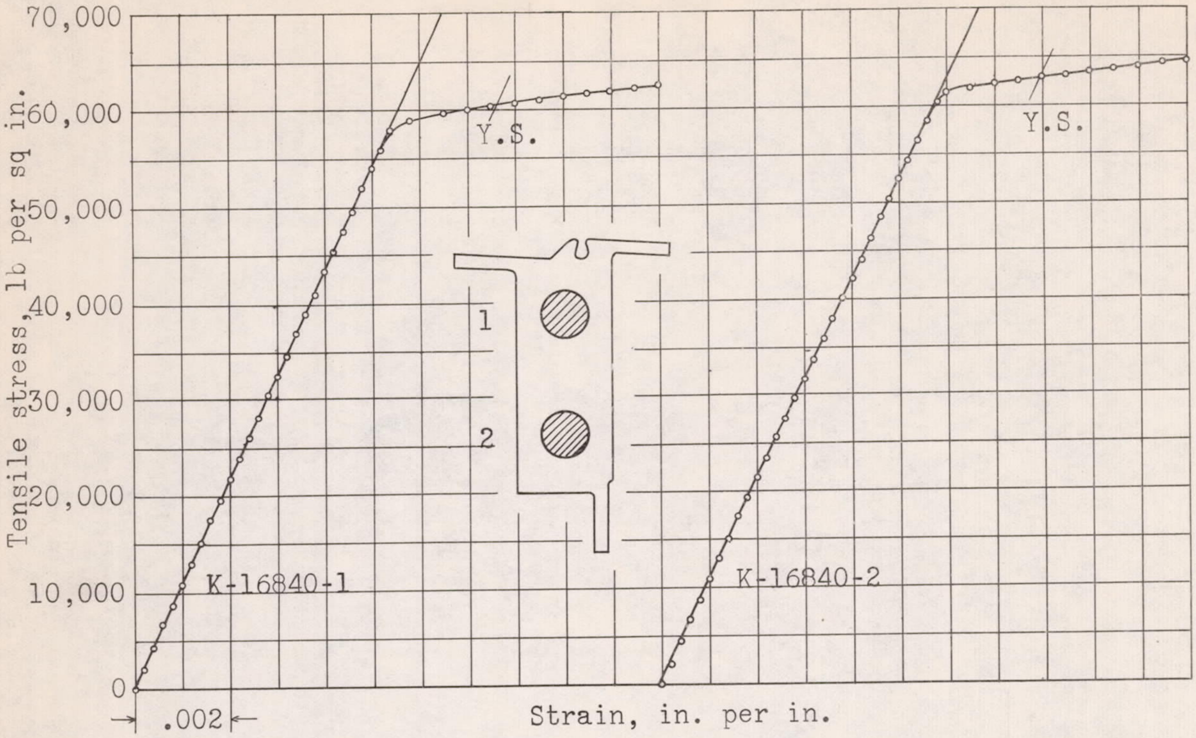


Figure 5.- Tensile stress-strain curves for 24S-T aluminum-alloy extruded shape.

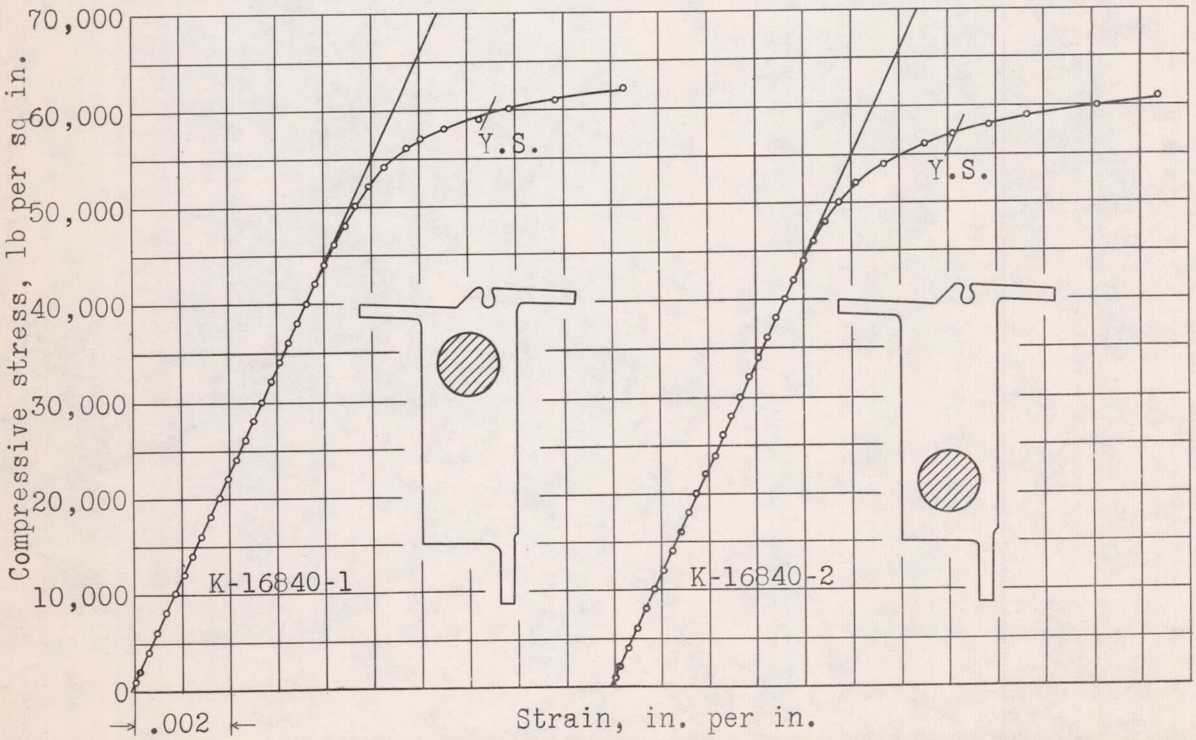


Figure 6.- Compressive stress-strain curves for 24S-T aluminum-alloy extruded shape.

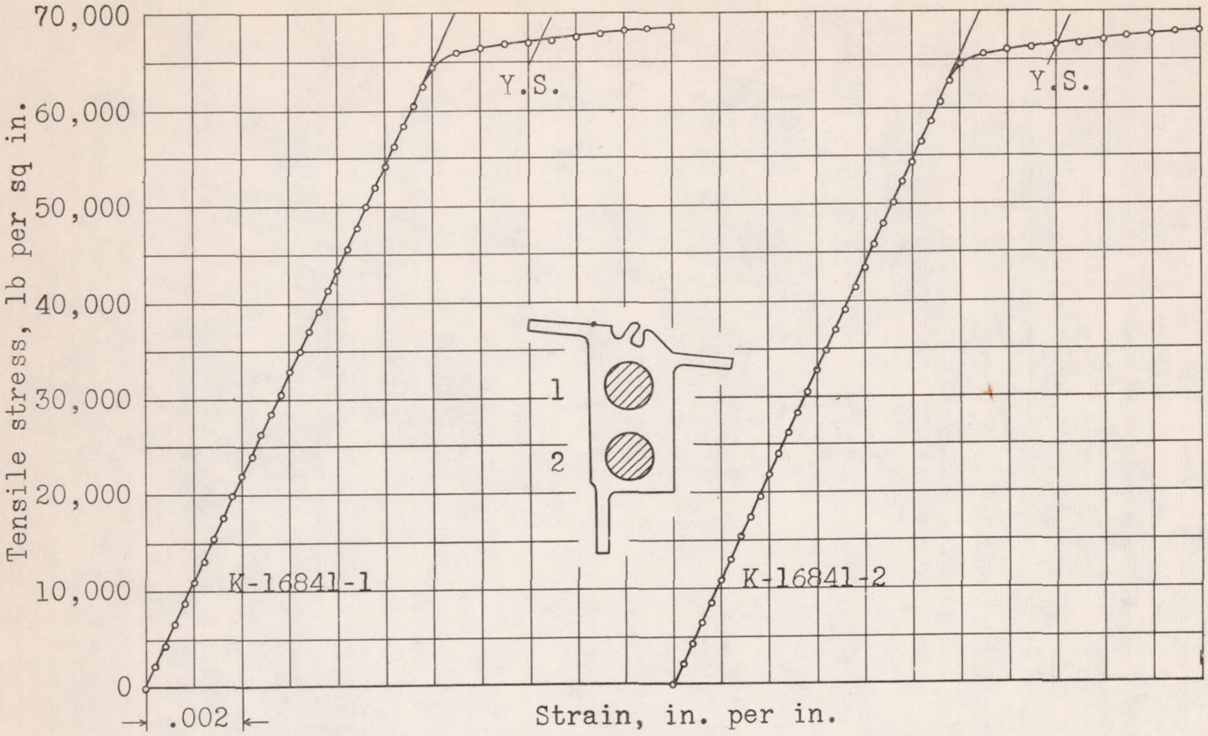


Figure 7.- Tensile stress-strain curves for 24S-T aluminum-alloy extruded shape.

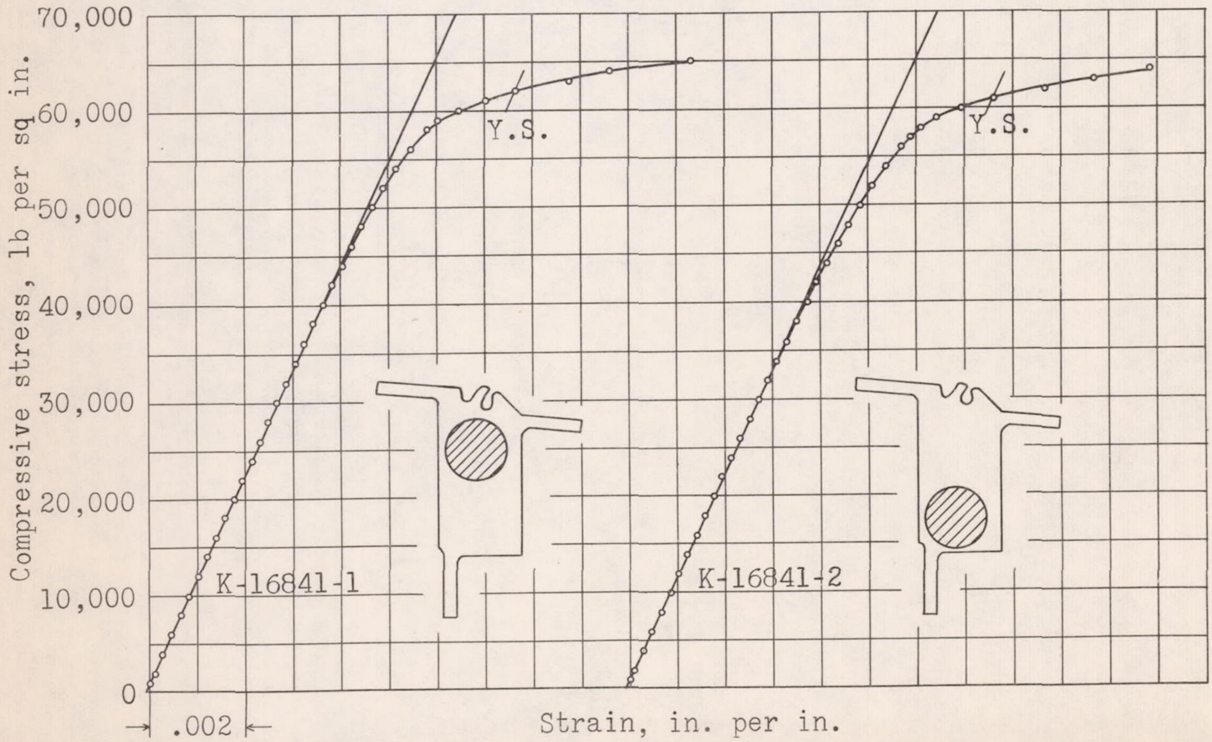


Figure 8.- Compressive stress-strain curves for 24S-T aluminum-alloy extruded shape.

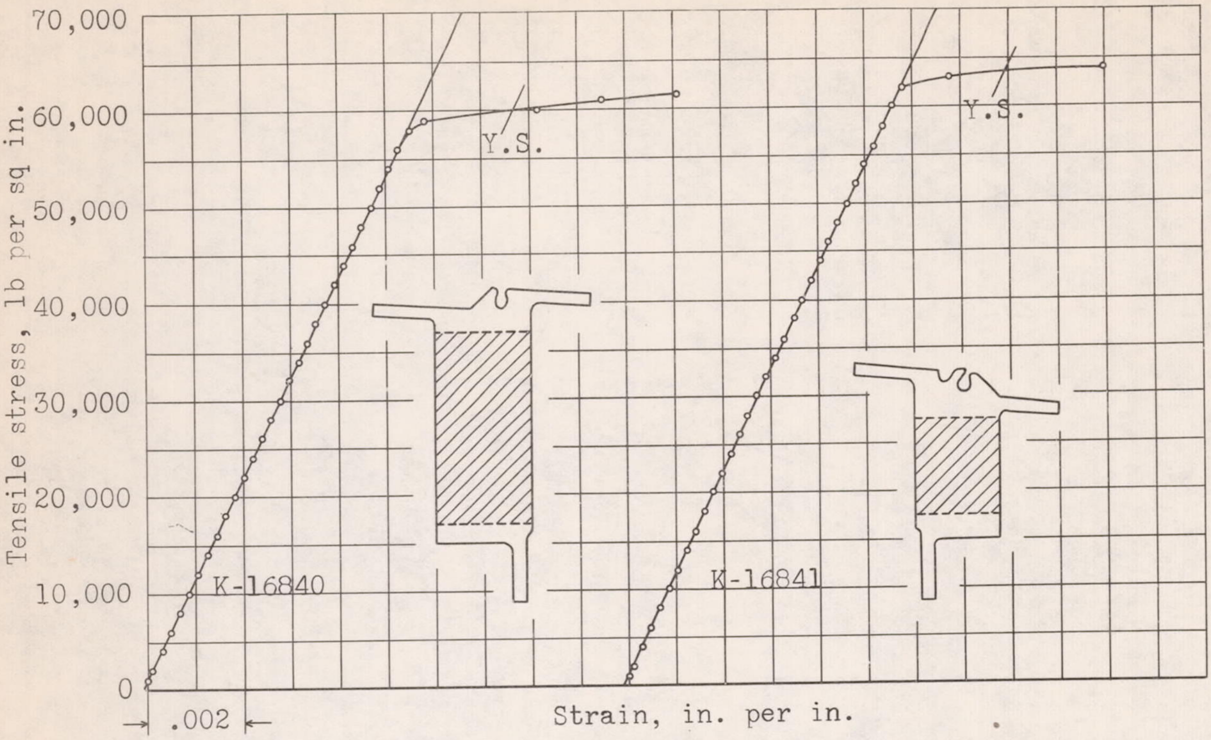


Figure 9.- Tensile stress-strain curves for 24S-T aluminum-alloy extruded shapes.

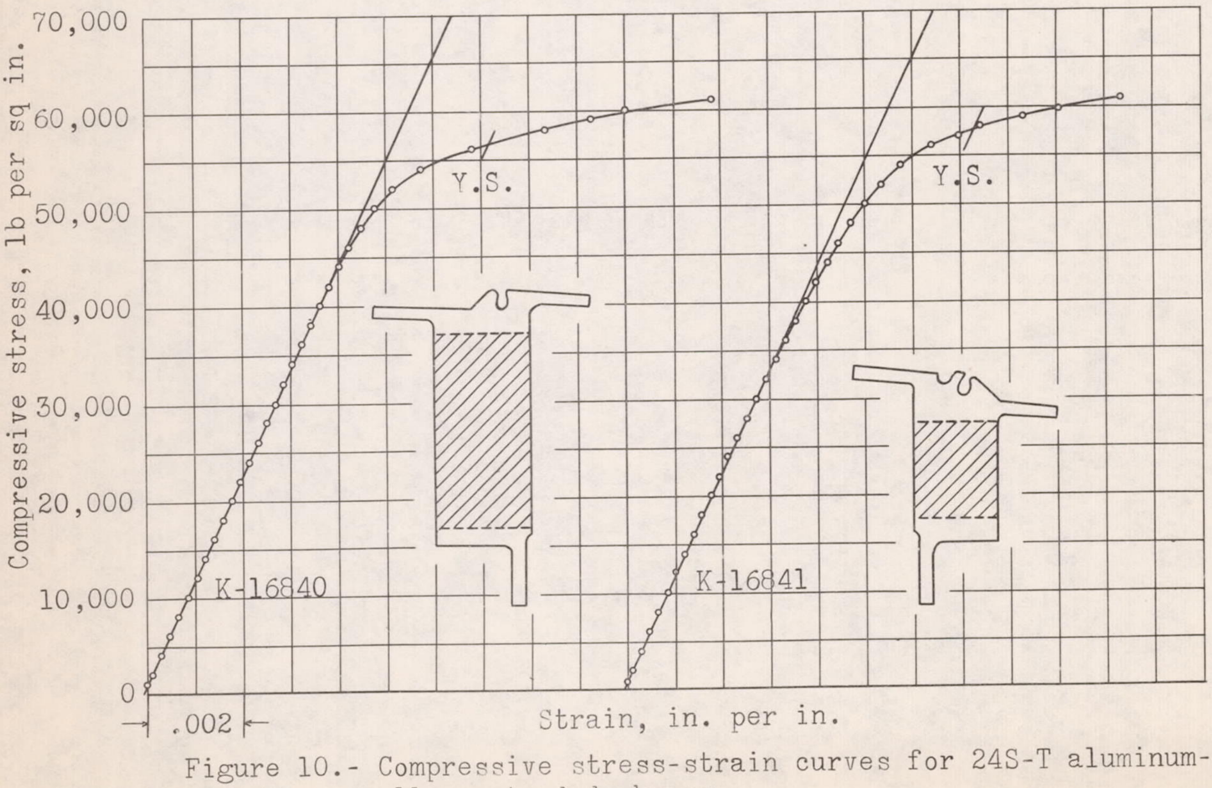
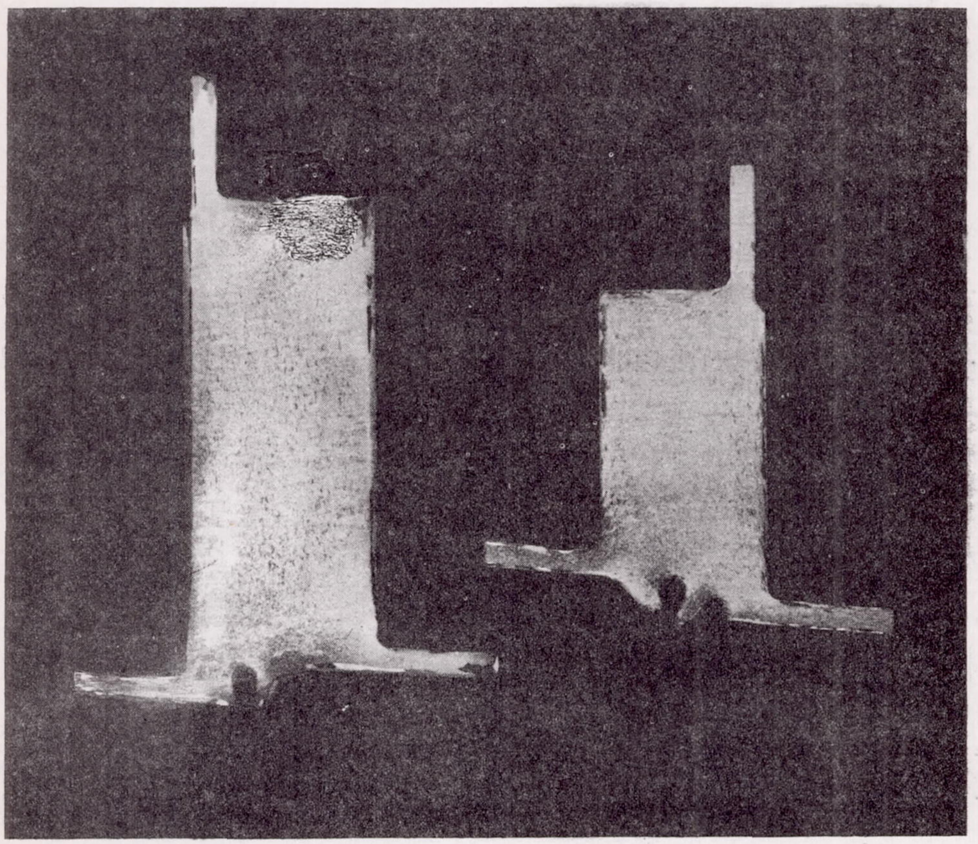


Figure 10.- Compressive stress-strain curves for 24S-T aluminum-alloy extruded shapes.



K-16840 K-16841

Figure 11.- Macrographs of extruded sections.
(full size)